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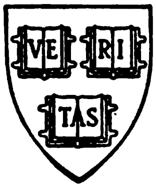
HARVARD UNIVERSITY



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AN EXPERIMENTAL STUDY ON THE CLEAVAGE OF THE CTENOPHORE EGG

N. YATSU

CAMBRIDGE, MASSACHUSETTS
1910

AN EXPERIMENTAL STUDY ON THE CLEAVAGE OF THE CTENOPHORE EGG

N. YATSU

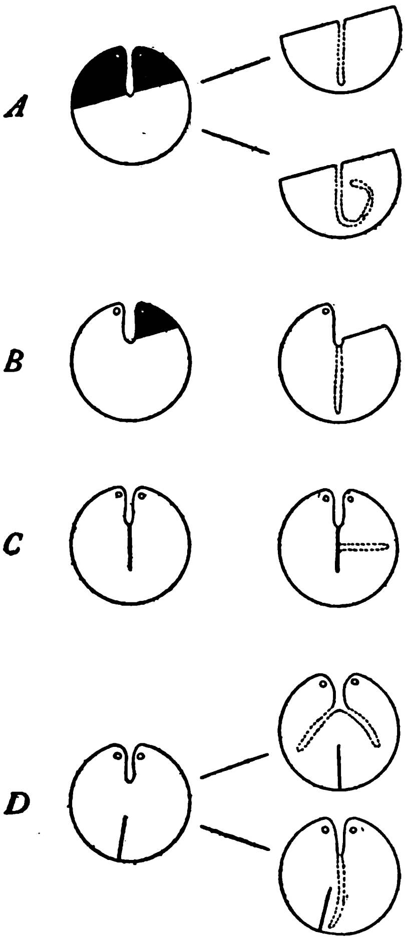
As to the mechanism of the cleavage of the ctenophore egg three explanations have been put forth. Ziegler maintains that an "action at a distance" by the centers causes the ring-like thickening of ectoplasm, which constricts the egg. Rhumbler interprets Ziegler's observations according to his theory. He assumes the presence of the nuclear fluid along the axis of the egg. After the cleavage furrow is formed by the contraction of the pole-rays, it deepens at the expense of the nuclear fluid. Moreover, at its bottom is a structure comparable to the centrosome ("Fürchenkopf"), which directs the growth of the membrane. Fischel incidentally expresses his view that there may be pole-rays, although we do not see them, and by the contraction of those rays the egg is cut in two.

Contrary to the usual view, the egg of *Beroë ovata* is an extraordinary structure, while its cleavage belongs to a rather common type. Ziegler and Rhumbler think that the entoplasm represents highly viscous deutoplasm. But as a matter of fact this substance is absent, as shown in the fixed material. The central mass is a watery alveolar substance, which Chun has correctly called "Zellsaft." Ziegler and Rhumbler maintain that the cleavage of Beroë is one-sided. But it is very clear that there is a vegetative furrow (although shallow) and a lateral elongation of the egg.

Now as to the cleavage-head. It is formed at first as a shallow indentation. As it grows deeper and deeper, beautiful spinnings of hyaloplasm are to be seen along the walls. The cleavage-head is a saddle-like thickening of ectoplasm, which shows a fine alveolar structure. Rays can be seen in the cleavage-head, but they do not extend into the entoplasm. Below are found compressed alveoli of entoplasm. This shows clearly that the cleavage-head is the structure which is itself actually pushing downwards instead of being pulled by the contraction of its rays.

In order to test the theories of the mechanism of cleavage of the Beroë egg I performed several series of experiments at Naples, of which four will here be mentioned.

EXPERIMENT A: The nucleated portion is cut off from the egg at different periods and levels (angles), and the behavior of the enucleated fragments is studied.



Result 1: Pieces deprived of the cleavage-head do not divide.

Result 2: Pieces with the cleavage-head divide. Neither nucleus nor center is necessary for cell constriction after the cleavage-head is established. This excludes the possibility that cleavage may be due to the tendency of the cytoplasm to assume a spherical form around the two centers (geometrical), because, if so, the cleavage-head would be pushed out and the egg fragment would resume its spherical form. The possibility that the cleavage head is formed by a down flow of ectoplasm from the animal pole is also eliminated.

Result 3: Division goes on at the normal rate or a little slower (15 μ per minute on an average). The growth of the cleavage-head is hardly influenced by the cytoplasm cut off.

Result 4: The cleavage furrow is sometimes straight. This shows that the amount of cytoplasm on both sides of the cleavage plane has nothing to do with the growth of the cleavage-head.

Result 5: The cleavage furrow sometimes doubles on itself and returns towards the animal pole. This makes Ziegler's ring theory improbable, because after the turn of the cleavage-head upwards the distance between it and the surface becomes greater. The curling-up of the cleavage furrow makes the presence of Rhumbler's supposed nuclear fluid axis impossible. It is interesting to note that the direction of curling of the cleavage furrow is independent of both the level and angle of cutting.

Experiment B: A portion containing one of the nuclei is cut off at different periods and levels (angles).

Result 6: The cleavage furrow goes down straight and cuts the egg in two. This is another proof of results 2 and 4.

Experiment C: The cleavage-head is split by a vertical incision at different periods.

Result 7: A new cleavage-head is formed a little below the original one, and cleavage proceeds at a right angle to the incision. In no case are two cleavage-heads formed.

Result 8: The cleavage-head is formed on the side with the larger amount of ectoplasm. This shows that a certain quantity of ectoplasm is important for the formation of the cleavage-head.

Experiment D: An incision is made at the vegetative pole.

Result 9: When the incision is median and vertical, then two cleavage-heads are formed, the egg being constricted into three lobes. This shows that the cytoplasm near the vegetative pole has something to do with the formation of the cleavage-head.

Result 10: When the incision is oblique, the cleavage goes on almost unaffected. That the cleavage-head passes close by the incision shows how little the cytoplasm at the side influences the cleavage.

Conclusion: The above experiments show that Ziegler's explanation is more satisfactory than Rhumbler's; yet it is not altogether correct, for the reason that both results 5 and 7 make the presence of an elastic ring improbable. Rhumbler's interpretation is also untenable. There is no membrane (pellicle) along the wall of the cleavage furrow. There is no visible axial differentiation in the entoplasm. Moreover, results 5, 7, and 9 disprove its presence. The cleavage-head does not exert a pull, but it is a structure of push, as shown by the absence of rays in the entoplasm and by the compressed entoplasm alveoli at its tip. The only plausible explanation is this. The egg of Beroë is cut by the contraction of the saddle-like (in later stages ring-shaped) accumulation of ectoplasm (the cleavage-head in optical section) uninfluenced by other structures, such as nuclei, centers, and amount of cytoplasm. Result 5 is obtained because the accumulation is shifted to one side by some unknown cause. Result

8 is produced also by unequal distribution of the accumulation. Result 9 is due to the splitting of the lower end of this accumulation by the vegetative incision. How this saddle-like accumulation of ectoplasm is formed is still uncertain. It may, however, be in some way related to the general migration of ectoplasm during the cleavage stages.

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